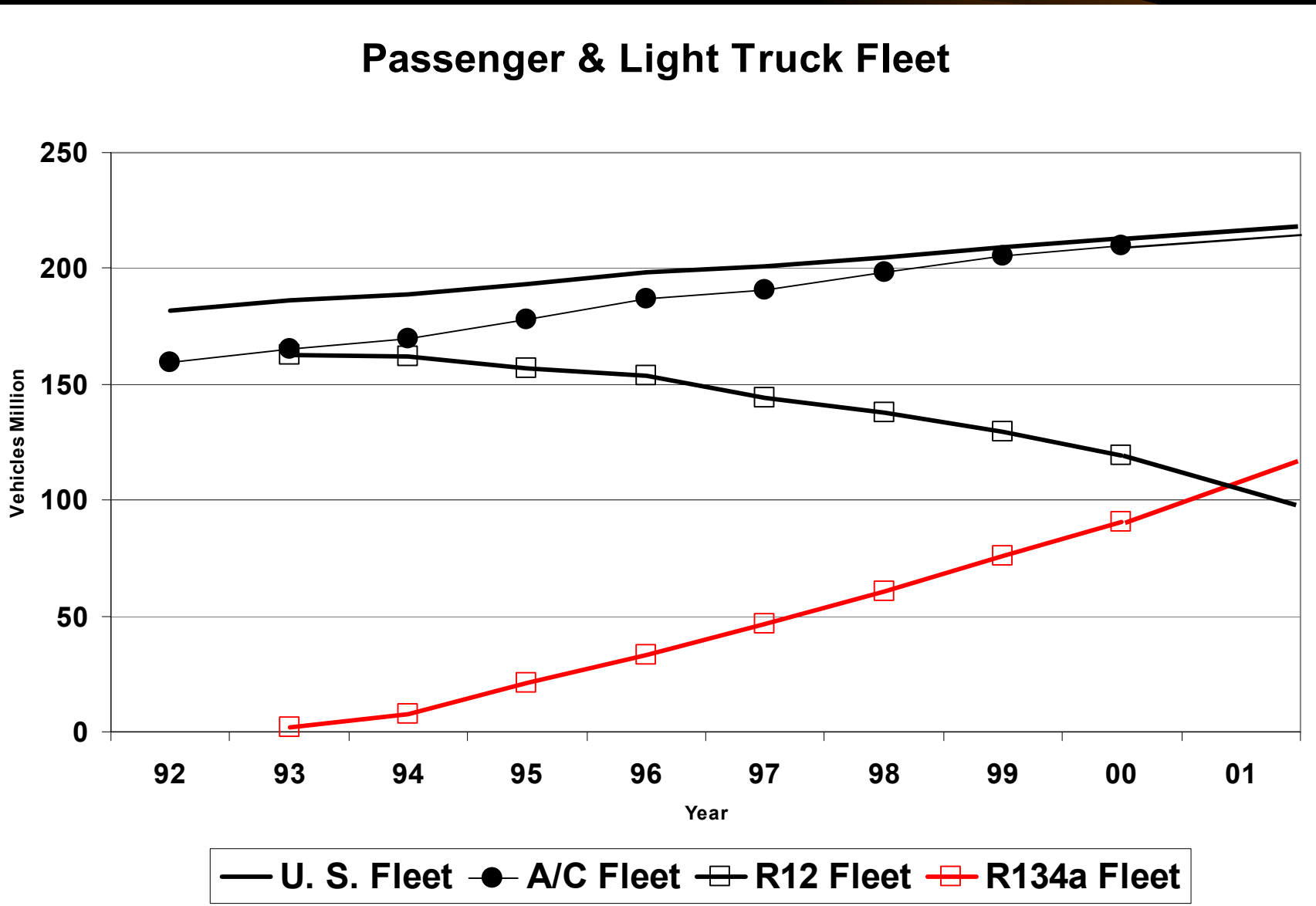
Greenhouse Gas Emissions From Vehicle Air Conditioning Systems

James A. Baker – Delphi Corporation

U.S. Fleet


Passenger & Light Truck Fleet
250
200
150
100
50
0
Vehicles Million
92
93
94
95
96
97
98
99
00
01
Year
U. S. Fleet
A/C Fleet
R12 Fleet
R134a Fleet

Servicing the CFC-12 Fleet

Legitimate Stockpiled or Recycled CFC-12
Or Relabeled & Smuggled CFC-12 ?

From This

Made in Mexico

To This

Sold in the USA

Penalties for Illegal Importation of CFCs

Those who illegally import CFCs or who sell or distribute CFCs that they knew were smuggled into the United States are subject to Customs law and Clean Air Act felony sanctions that are punishable by up to 5 years of imprisonment and up to $500,000 in fines per violation. Further those who evade or fail to pay the requisite excise tax due on the first sale or use of the CFC in the U.S. are subject to criminal tax violations and money laundering charges that are punishable by up to 20 years.

A/C System GHG Emissions

- **Direct - Refrigerant Emissions**
  - System Leakage
  - Vehicle Accidents
  - Losses at Service & Scrap
- **Indirect - Tailpipe CO_2**
  - from fuel to operate A/C
  - from fuel to carry A/C weight

Methods To Compare A/C Systems' Contribution to Global Warming

Total **E**quivalent **W**arming **I**mpact

Life **C**ycle **C**limate **P**erformance

Global Climate Impact of Automotive AC Systems

	LCCP Cradle-to-Grave Emissions	TEWI In-Use Emissions
Production Energy - All Materials	■	
Refrigerant Emissions		
Refrigerant Mfg Losses	■	
Vehicle System Leakage	■	■
Vehicle Service & Scrap Losses	■	■
Vehicle Accidents	■	■
Energy to Carry A/C System Mass	■	■
Energy to Operate A/C System	■	■
Energy Required for re-claim and re-cycle all A/C system materials	■	

U.S. EPA SNAP 'Acceptable' Refrigerants for Vehicle Air Conditioning Systems

HFC-134a ←

- **Only OEM approved refrigerant**
- **Only SNAP refrigerant with unique service fittings and recovery/recycling equipment**

All others contain HCFC's

{Ozone Depleting and Potent GHG Chemicals}

- **Free Zone / RB-276**
- **R-406A / GHG**
- **GHG-X4 / Autofrost / Chill-it**
- **Kar Kool**
- **GHG-X5**
- **FRIGC FR-12**
- **Ikon-12**
- **GHG-HP**
- **Hot Shot / Kar Kool**
- **Freeze 12**
- **SP34E**

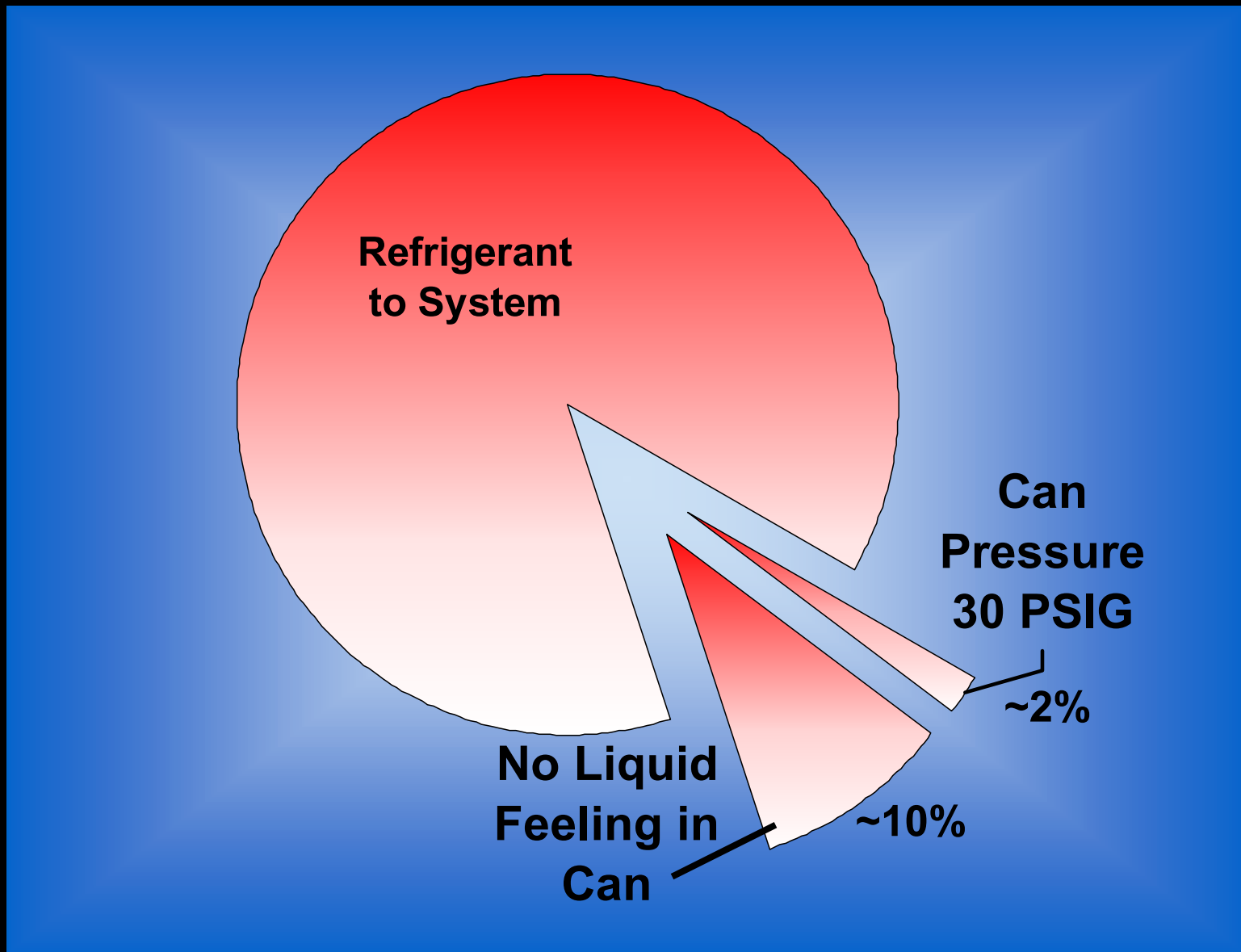
U.S. EPA SNAP 'Acceptable' Refrigerants for Vehicle Air Conditioning Systems

- **EPA "acceptable" service refrigerants**
  - **Have not been tested by EPA**
  - **None have industry recognized recovery/recovery service equipment**
- **When used, have high potential to be vented at service**
- **Generally available in small cans and 30# containers**

Sale of HFC-134a

- General public can purchase HFC-134a and charging hoses
- Clean Air Act prohibits venting of CFC-12 and HFC-134a during service
  - Recovery & recycling equipment required at service facilities
- DIY'ers must comply with non-venting rule – enforcement lacking

12 Ounce Can Residual Refrigerant Losses



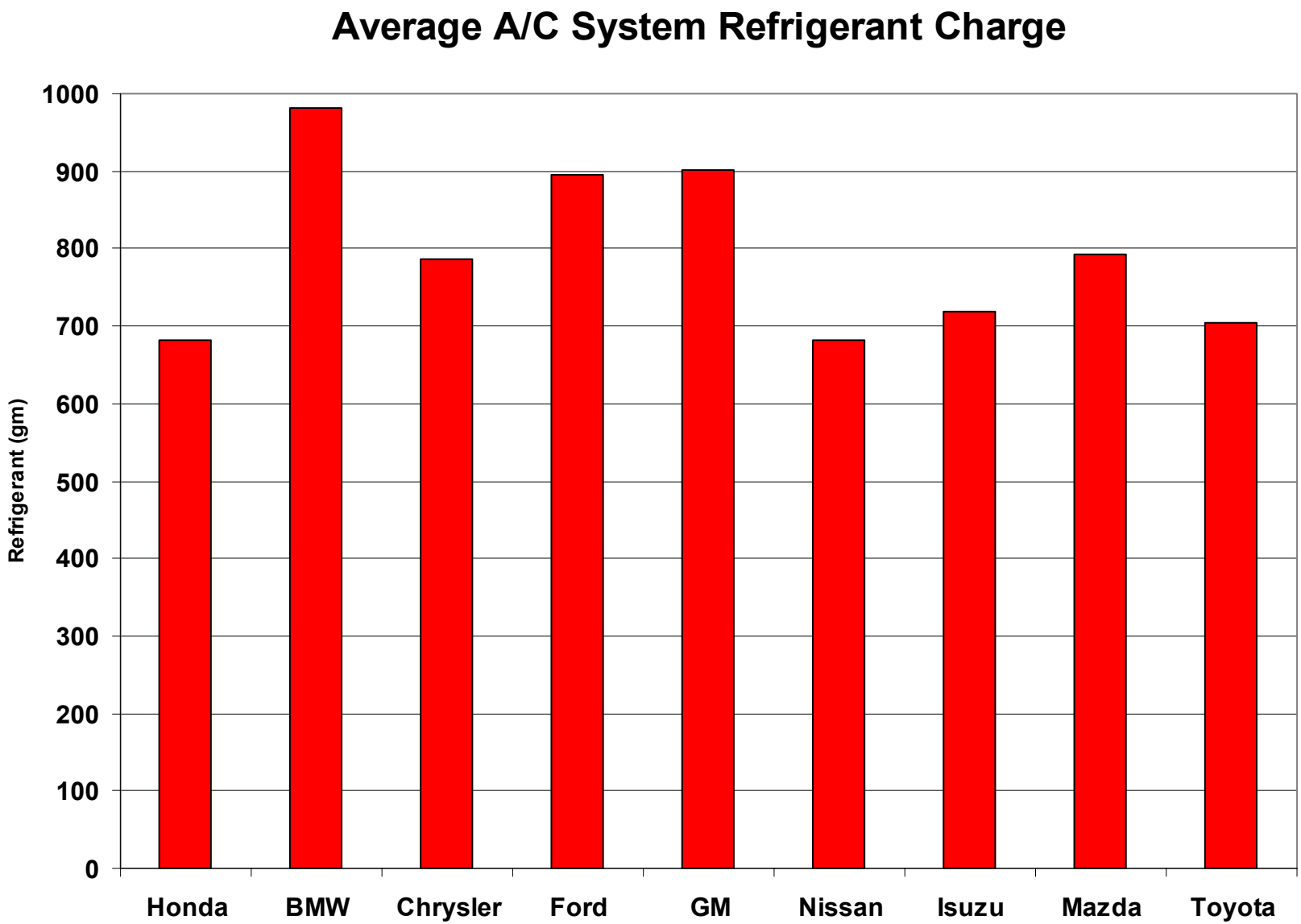
Sale of HFC-134a

- **Original EPA Rule** (Section 608 of the Clean Air Act, No. 63FR0243) to restrict the sale of HFC-134a to certified technicians.
  - October 8, 1998 MACS Letter To Congress

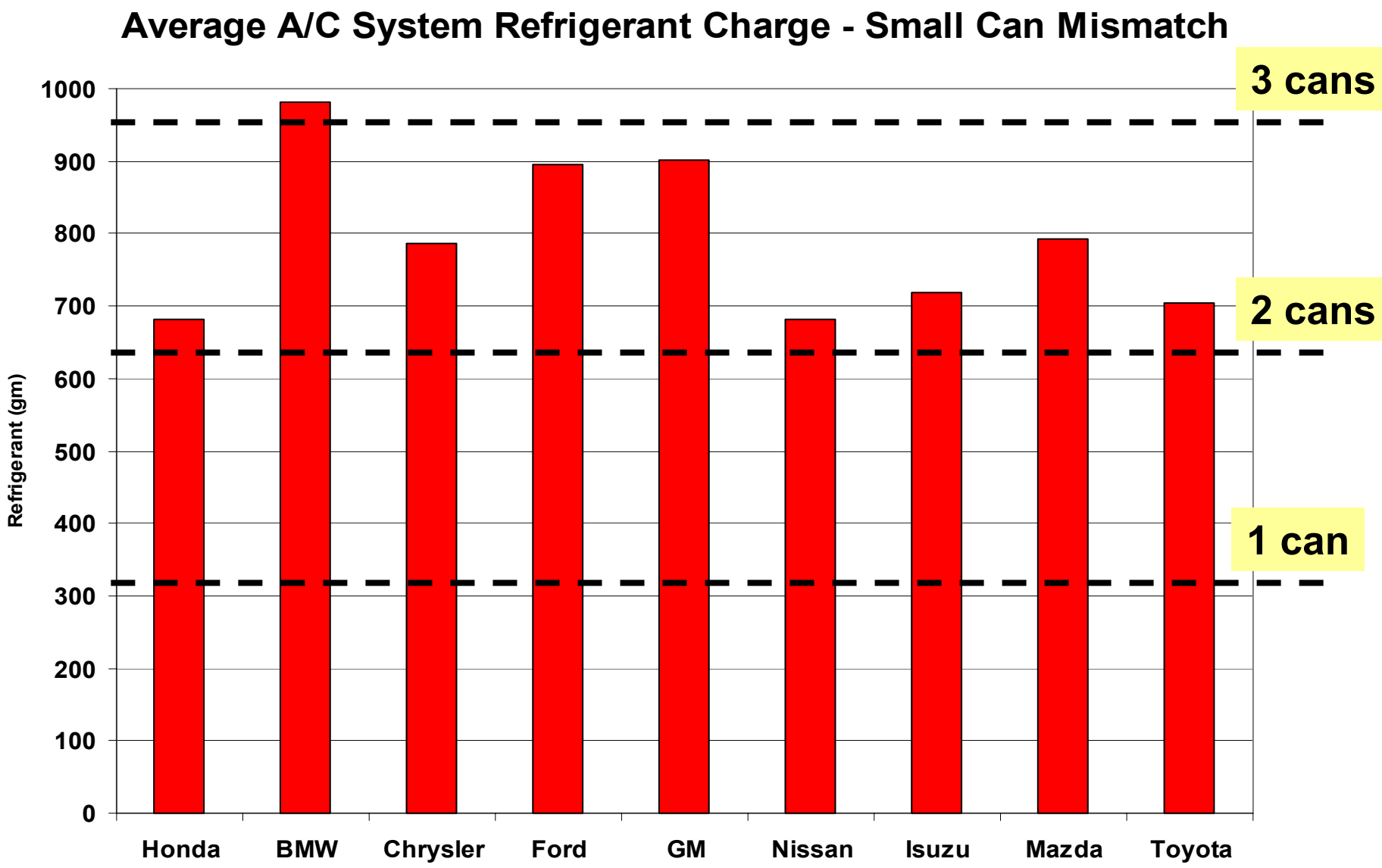
Annual atmospheric residual release from 53 Million small (12 oz.) cans

4 Million Pounds

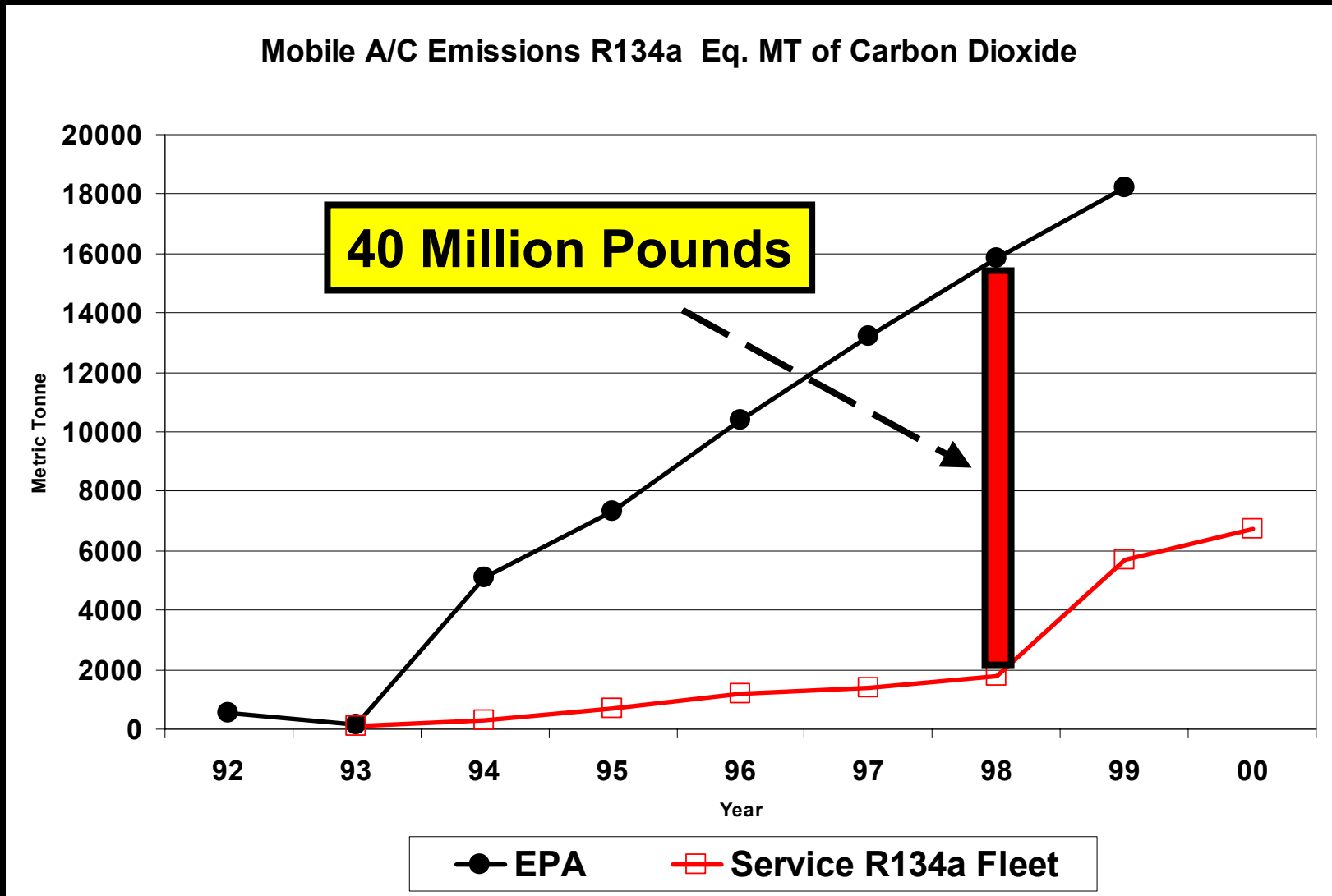
Typical Production HFC-134a



Typical Production HFC-134a



HFC-134a Emissions Gap

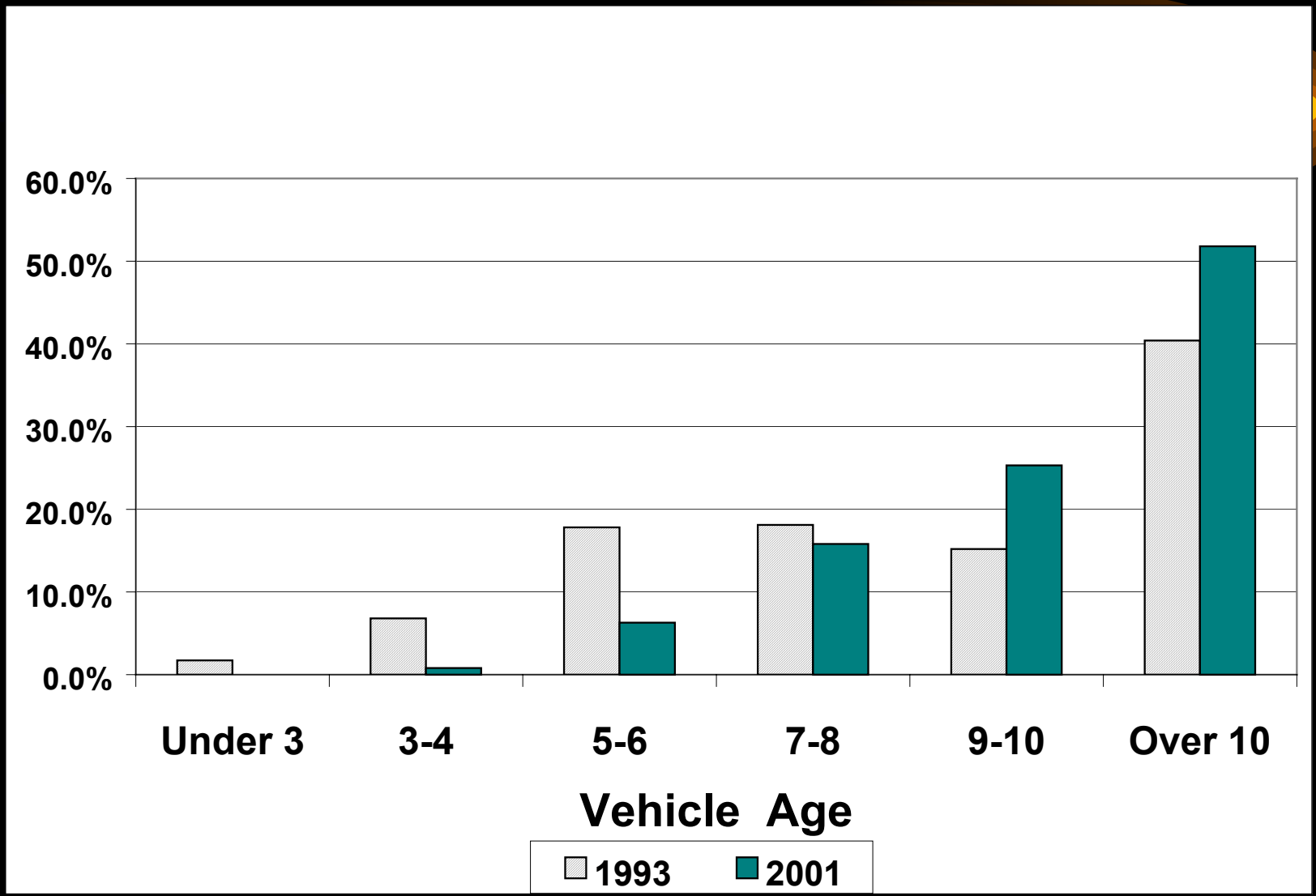


MAC System Service & HFC-134a Emissions

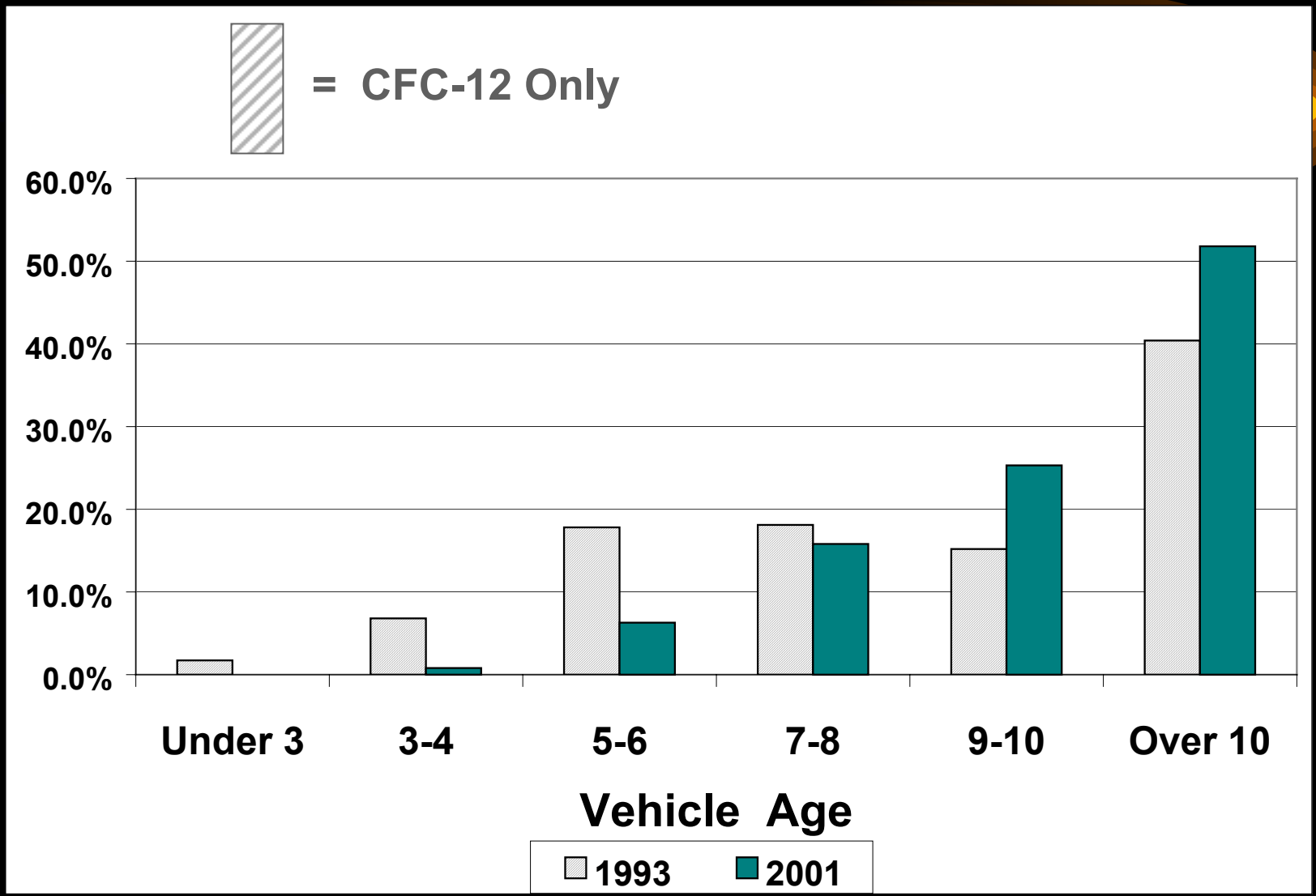
- Are HFC-134a Systems Really an Improvement Over CFC-12 Systems ?

- Service Experience Says Yes!

Vehicle Service Profiles



Vehicle Service Profiles



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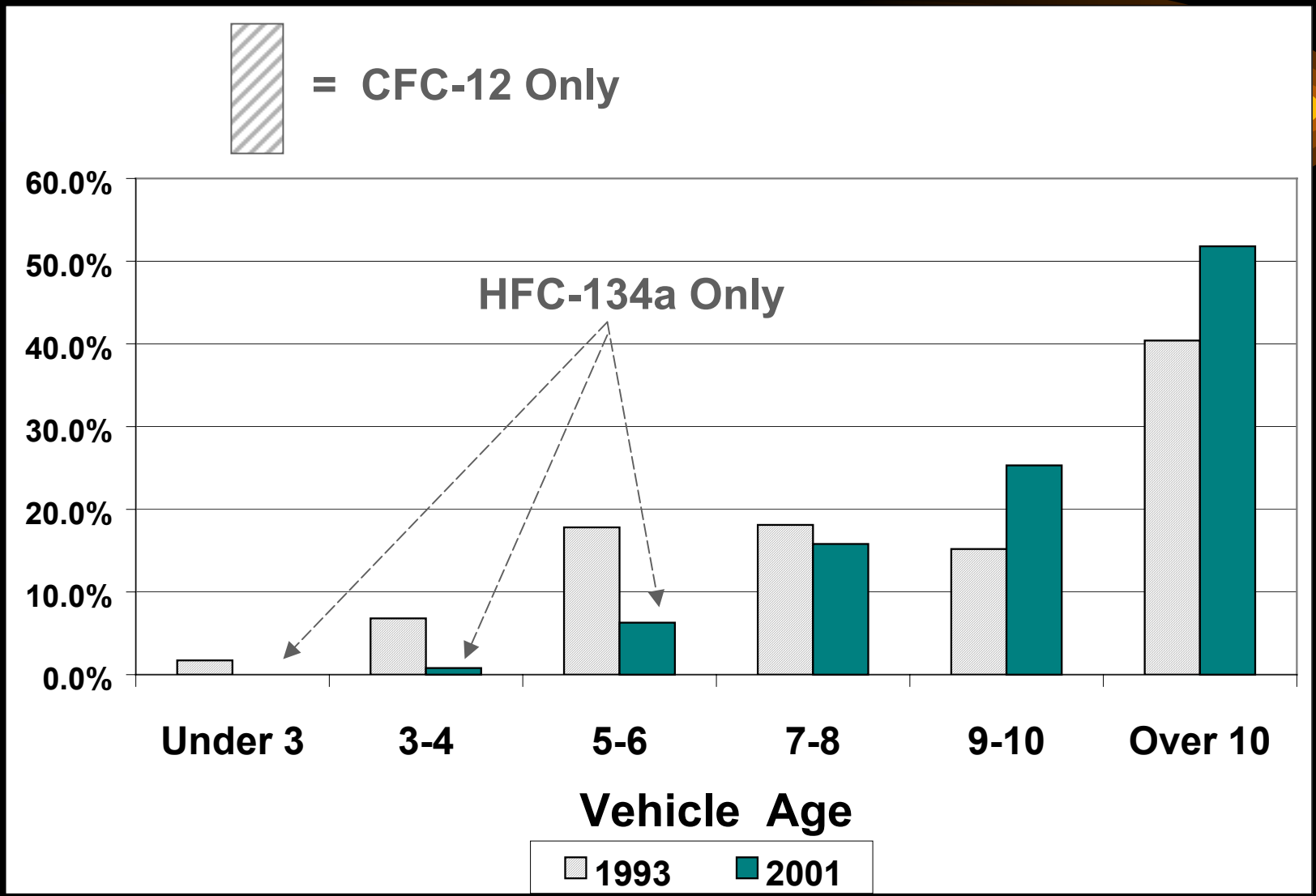


Designs are Improving

- European Leakage Measurements - 2002

  57 grams / system / year

- General Motors 2002 Leakage Specification

  25 grams / system / year

Speech by Commissioner Margot Wallström

Commission Conference "Options to Reduce Greenhouse Gas Emissions due to Mobile Air Conditioning"
Brussels, Feb 10-11, 2003

EU Challenge

"… The challenge …. is that air-conditioning makes a growing contribution to total greenhouse gas emissions from passenger cars."

"… This makes it clear that we need to take action to reduce emissions from mobile air-conditioning units.

"… Phasing out (*HFC-134a)* is one option, but we are happy to consider alternative paths if they are promising."

Speech by Commissioner Margot Wallström

Mobile Air Conditioning Systems

- Environmental issues
  - Type of refrigerant
  - A/C system weight
  - Energy consumption
- Safety issues
  - Type of refrigerant
    - Occupant and service technician exposure
  - System's ability to provide occupant comfort and clear vision during inclement weather

Mobile Air Conditioning Systems (Future)

- More efficient HFC-134a systems
- Carbon dioxide (CO_2) cooling and heat pump systems
- Secondary loop cooling systems
- HFC-152a systems
- Hermetic (sealed) electric compressor systems

Mobile Air Conditioning Systems (Future)

- Electronic controlled
  - Compressors
  - Refrigerant system controls
- New service equipment
- Improved service technician training
  - More complex systems for DIY'ers to repair

Pros and Cons of Options for Vehicle Air Conditioning

Improved HFC-134a

CO_2 (R-744)

HFC-152a

HFC-134a

Pros

- Current established technology
- Intrinsically safe (non-toxic, non-flammable)
- Demonstrated potential for improved energy efficiency (SAE ARCRP)
- Potential for reduced direct refrigerant emissions
  - Improved system design
  - Improved refrigerant handling in field

Cons

- High GWP refrigerant
- Cost of recycling/recovery
- Cost of design improvements to reduce leakage
- Cost of refrigerant, including taxes?
- Limited heat pump performance

CO_2 (R-744)

Pros

- GWP = 1
- Non-HFC / natural fluid
- Non-flammable
- More rapid cool-down
- Reduced compressor size
- Eliminates need to recycle
- Good heat pump performance (heat pump technology not yet developed for vehicles)
- Low refrigerant cost

Cons

- High pressure system
- New system & component designs required
- High tooling / production cost
- Needs internal heat exchanger
- Flexible lines still unresolved
- Safety system needed
- Increased system weight
- Full efficiency potential needs to be demonstrated
- System leakage
- Leak detection method needed
- Training of personnel

HFC-152a

Pros

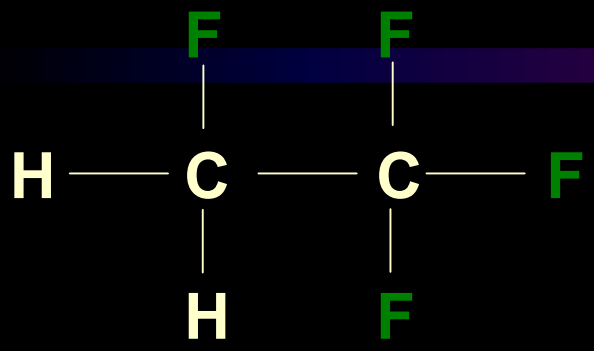
- Low GWP refrigerant
- Same system components as HFC-134a - easy to introduce
- Same potential for improved efficiency as HFC-134a
- Reduced refrigerant charge and leakage rate
- Low cost

Cons

- Flammable gas
- Safety system needed
- Recycling/recovery still required
- Training of personnel
- Industry acceptance ?

Why R-152a?

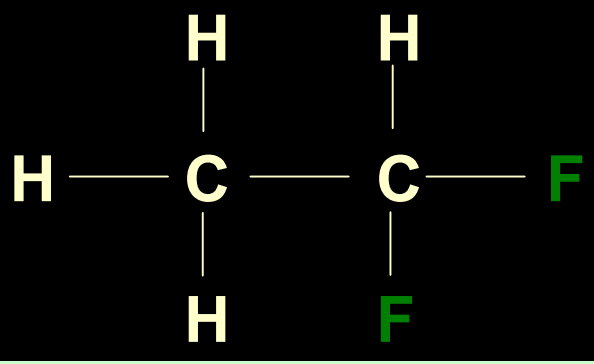
Chemically Similar – Environmentally Very Different



R-134a Molecular Weight = 102

ASHRAE A1 – Non-flammable

GWP = 1300



R-152a Molecular Weight = 66

ASHRAE A2 - Flammable

Similar Materials Compatibility

GWP = 120

94% Reduction in Climate Impact from Refrigerant Change

Combination of reduced GWP + reduced refrigerant charge

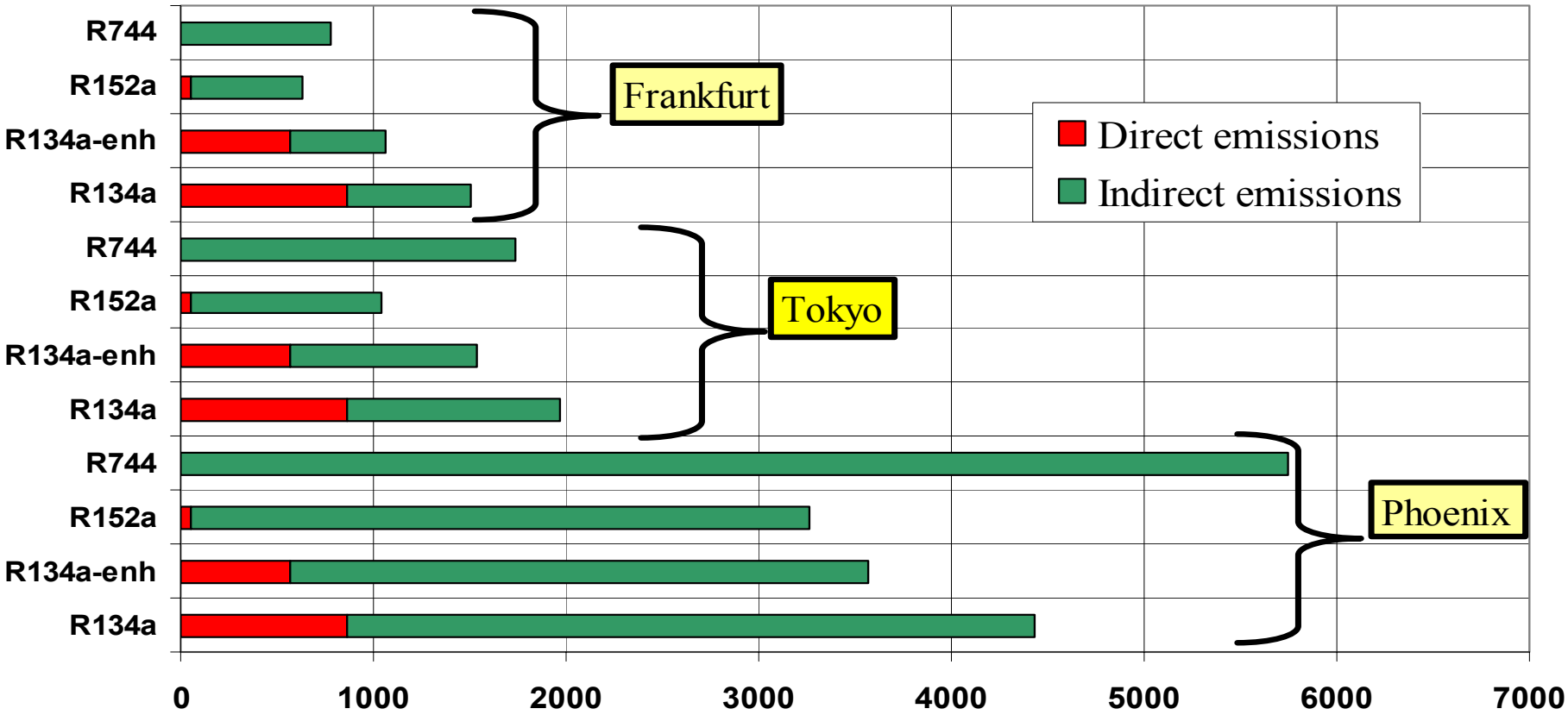
(Does not including energy savings)

MAC Summit Review
(Status and Comparison of Options)

A/C System Choice	Reduced Direct Emissions	Reduced Indirect Emissions	Added Cost (Euros)	Time to Market (Years)
HFC-134a	Baseline	Baseline	Baseline	Current
Improved 134a	50%	25%	20	1 - 3
HFC-152a	94%	10%	15	4 - 6 Market Acceptance ?
Secondary Loop 152a	96%	Baseline	40	
Future 152a	94+%	30+%	35	
CO_2	100%	1%	40-180 *	6 - 11 +? Technical Hurdles Cost
Future CO_2	100%	?	?	

* Excludes retooling

LCCP Analysis
Comparison of current & enhanced R-134a, R-152a, and R-744 Vehicle A/C Systems Versus Climate



kg CO_2 (equivalent)

European Climate Change Programme: legislative action fluorinated gases

Phil Callaghan
European Commission
DG ENV.E.1

Outline of Commission proposal

Commission proposal will address 3 aspects:

1. **Containment**
2. **Data reporting**
3. **Use controls**

Containment

- Recovery - mandatory for most equipment
- Recycling or destruction – mandatory
- Disposable containers - banned except for medical and laboratory uses
- Annual inspection for leakage – mandatory
- Duty on users to minimise leakage
- Minimum qualifications - set by Member States

Use bans

- Early bans - based on ECCP report
- Establish criteria for future bans
  - safety and health
  - cost-effectiveness
  - technical feasibility
- Management Committee to consider future bans and derogations

Consultation and timetable

- Ongoing - working group continues to meet
- March 2003 - DG ENV begins to draft legislation and explanatory memorandum
- Commission adopts proposal no later than September 2003

What about MAC?

We have a problem: 18.7 $MTCO_2$ eq. or 38 $MTCO_2$ equivalent

<u>But</u> we have solutions:

- **containment - inspect, recover, recycle, train servicing personnel, certify refrigerant handlers**
- **better design - enhanced HFC-134a**
- **alternative technologies**
  - HFC-152a, CO_2 and HC

Overview of the Industry

- Need for service – depends on system leakage rate
- Today's systems are much better than in the past
  - Current spec is 25 g loss per year per vehicle (equates to one recharge or less per lifetime compared to 3+ with CFC-12 systems)
- Uncontrolled sale of R-134a undermines efforts to reduce emissions
  - highly emissive activity – lack of R&R
  - no repairs needed
  - can repeatedly recharge leaky systems
  - can retrofit leaky systems

Overview of the Industry

- All users of refrigerant should be required to have and use recovery & recycling equipment
- Much can be done to responsibly handle refrigerants
- Alternative refrigerants

  CO_2 – overcoming technical hurdles and high costs

  R-152a – safety assurance and customer acceptance
- Europeans pressuring industry to reduce emissions and commercialize alternatives
- A/C energy use may not be a major problem, but we can lower it with proper system controls

Alternate Refrigerant Stakeholders